# The water-energy-carbon nexus: Optimising the BECCS supply chain

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## The necessity of Negative Emissions Technologies

BECCS is a promising technology to reach the IPCC’s fifth assessment 2°C scenario…

- BECCS is based on the carbon neutrality of the biomass, combined with capture of CO₂ produced by combustion of this biomass and its storage in geological or ocean repositories.
- BECCS is a key technology aimed to decarbonise the atmosphere.

**But controversial**
- UK goal: remove 50 MtCO₂/year by 2050
- Which type of biomass, from which region should be used in order to minimize the water/land footprint of BECCS supply chain?

## Software Integration and Model Framework

### Input Data
- Biomass data: crop characteristics, etc.
- Region data: region characteristics, weather characteristics, etc.
- Land type data: SUIC & ELUC.
- Energy & carbon data: fuel, chemicals, etc.

### Supply chain & Power plant Model

**BECCS Optimisation Model**  
500 MW Power Plant

![BECCS Optimisation Model Diagram](image)

**Intermediate Outputs**  
Biomass Supply Chain  
- Carbon footprint  
- Water footprint  
- Energy footprint  
- Land footprint

**BECCS**  
- Carbon intensity  
- Water intensity  
- Energy intensity  
- Land intensity

**Minimial Constraint:**  
- Water Intensity \( \text{m}^3/\text{year} \)
- Or Land Footprint \( \text{ha/year} \)

### Choose BECCS Scenario

- Biomass Supply Chain
- Biomass type: Miscanthus, Switchgrass, Wheat straw and Willow

### BECCS

- Capture Rate \( 60-90\% \)
- Co-firing proportion \( 0-100\% \)

### BECCS Optimisation

**Main Objective & Constraint**
- Carbon Removal Target \( \text{tCO}_2/\text{year} \)
- Arable Lands Availability \( \text{ha/year} \)

**Minimal Constraints**
- Water Intensity \( \text{m}^3/\text{year} \)
- Or Land Footprint \( \text{ha/year} \)

**Other Constraints**
- Total Carbon Removed \( \text{(Region, Biomass, Land type)} \)
- Carbon Removal Target
- Biomass, Biomass Availability \( \text{(Region, Biomass)} \)
- Arable Lands Availability \( \text{(Region, Land type)} \)

### Software Integration and Model Framework

**BECCS : TRADE-OFF BETWEEN MINIMIZING ITS WATER INTENSITY AND ITS LANDFOOTPRINT**

- Satisfy UK Carbon Removal Target: \( 50 \text{MtCO}_2/\text{year} \)
- Choose how much biomass, in which region of the world, on which land type should be used while:
  - Minimising BECCS water intensity,
  - Or minimizing BECCS land footprint.

### Minimizing BECCS Water Intensity

Which biomass/combination of biomass is required to capture 50 MtCO₂ while minimizing the water intensity of BECCS?

- Total amount of used water: 315 Gm³.
- Total amount of cultivated land: 38.5 Mha.

To minimize the water intensity of BECCS, Miscanthus is cultivated in Europe as much as possible and then in Brazil and in China to meet the carbon removal target, on a marginal land.

### Minimizing BECCS Land Footprint

Which biomass/combination of biomass is required to capture 50 MtCO₂ while minimizing the land footprint of BECCS?

- Total amount of used water: 325 Gm³.
- Total amount of cultivated land: 32.8 Mha.

To minimize the land footprint, Miscanthus is cultivated in Brazil, in China and then in the US on a marginal land.

### Conclusions

- Miscanthus is used in both scenarios, on a marginal land.
- The biomass availability is a key parameter.
- The criteria to be minimized plays a decisive role in the determination of the region where the biomass is cultivated.

### What’s next?

Developing the optimisation tool to:
- Maximize BECCS net energy provided,
- Create a 3D Pareto surface.

## References

[Fuss et al., Nature Climate Change, 2014]